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1 January 1964

The Size of Edge Gradient Objects

The required size of edge gradient objects is determined by the magnitude of the image spread. An estimate of required dimensions can easily be made after doing the arithmetic for some nicely behaved functions.

Assuming the optical transfer function is even (i.e., no phase shift) and gaussian, then the line spread function is also gaussian, and the edge gradient is the error integral. For this case, Figures 1, 2 and 3 reveal that the image of a sharp edge object is "enlarged" to slightly more than twice the reciprocal of the limiting spatial frequency. Figure 4 illustrates the effect of this edge "enlargement" on the image of the proposed four-patch target object. Figure 5 relates patch size to microdensitometry requirements.

In Figure 6, a somewhat smaller four-patch target is illustrated. It still contains the four long edges and sufficient area adequately remote from edges to give reliable brightness data. A moderate safety factor is illustrated for Dimension A.

To get a better feeling for the reasonableness of the suggested safety factor, the dependence of the suggested size on the gaussian transfer function assumption is next considered. An exponential transfer function produces an inverse tangent edge gradient. This gradient approaches the patch brightness asymptote very slowly and thus would require a patch nearly fifty times larger than the reciprocal of the limiting spatial frequency. (See Figure A-1, A-2 and A-3.) If, however, the patch is the previously suggested four or five times the reciprocal of the limiting spatial frequency, the brightness gradient would be within 11% of the asymptotic value rather than the 1% difference for a gaussian transfer function. Conversely, linear image motion gives a linear-ramp gradient and only produces a spread equal to the reciprocal of the limiting spatial frequency. (See Figures A-4, A-5 and A-6.)

The attached table gives ground dimensions, based on a gaussian transfer function, for two systems for current interest and also for a hypothetical system. Allowing for non-nadir viewing and other pessimistic factors, the table contains suggested dimensions for four-patch targets of the form illustrated in Figure 6.

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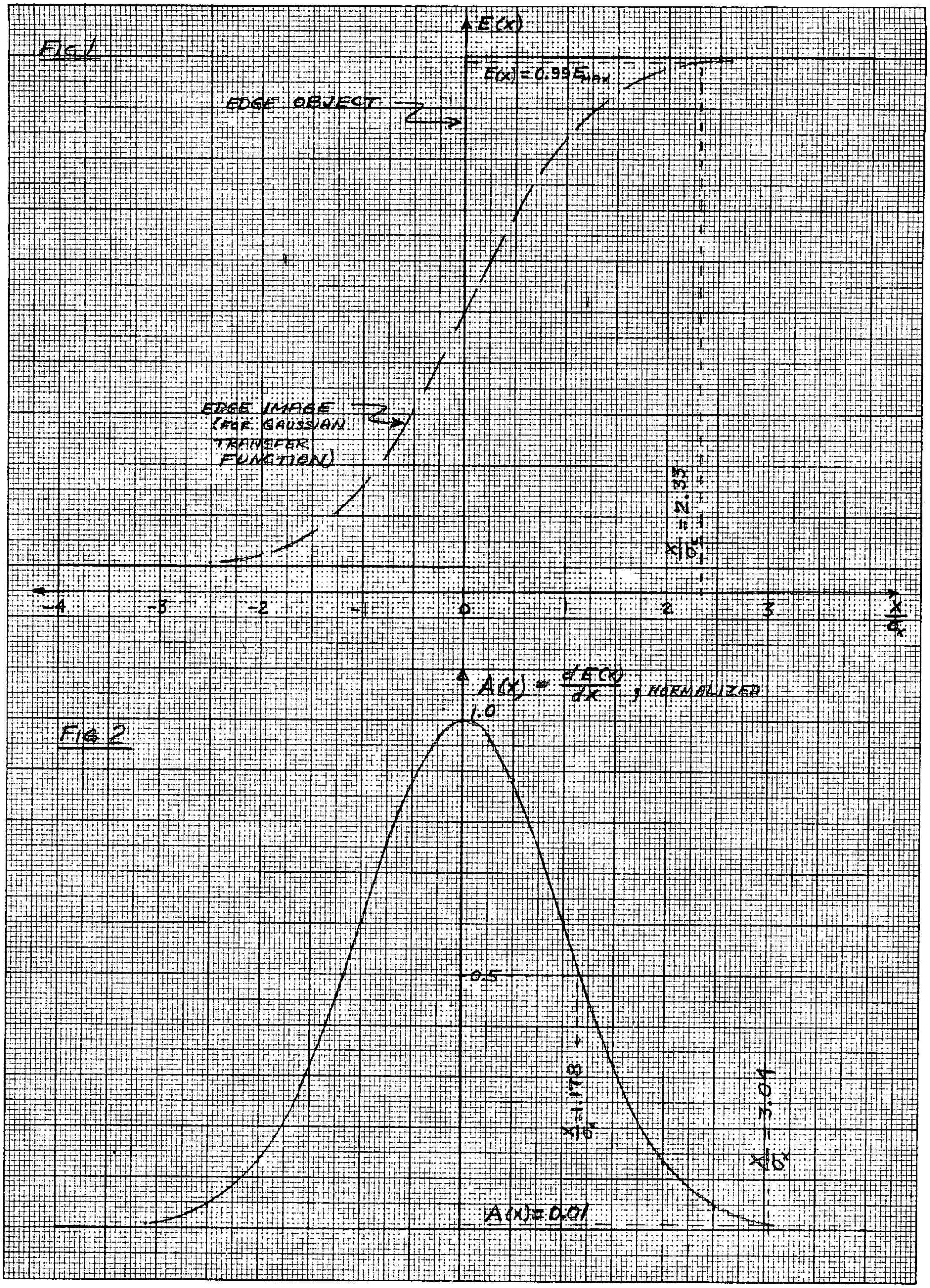
FIG. 1
E(x)
E(x) = 0.99 E_MAX
EDGE OBJECT
EDGE IMAGE (FOR GAUSSIAN TRANSFER FUNCTION)
x/σx = 2.33
-4
-3
-2
-1
0
1
2
3
x/σx
FIG 2
A(x) = dE(x)/dx ; NORMALIZED
1.0
0.5
x/σx = 1.178
x/σx = 3.04
A(x) = 0.01

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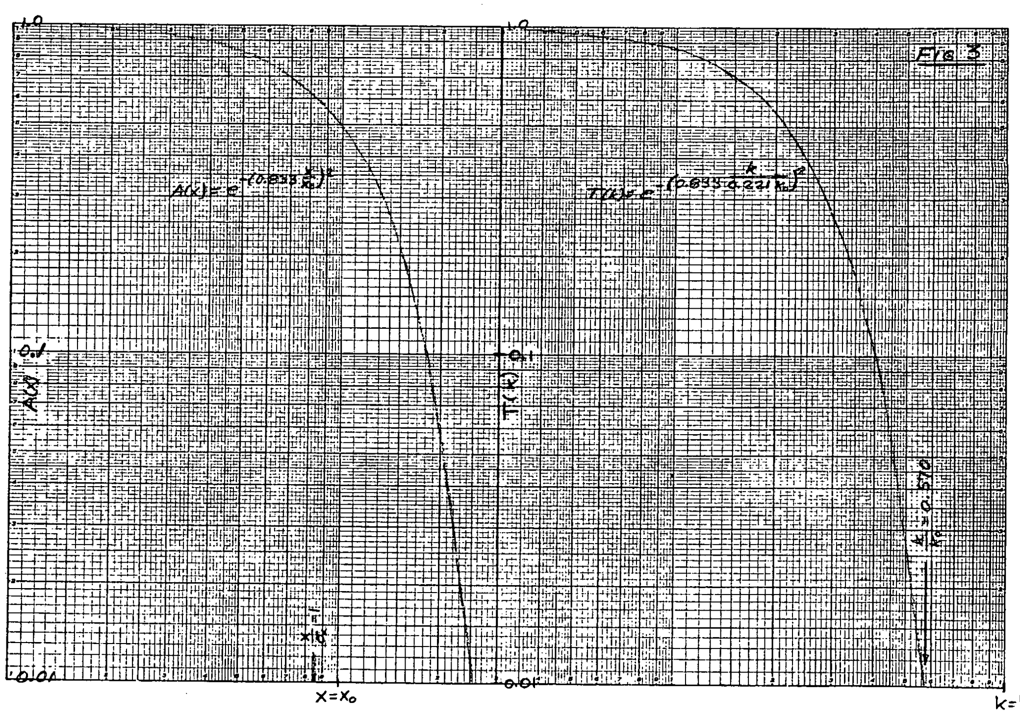

$D_{SPREAD} \geq 2(2.33\sigma_x) = 4.66(0.85X_0) = 3.96\frac{1}{k_0} = 3.96\left(\frac{0.570}{K_{1\%}}\right) = 2.26\ K_{1\%}^{-1}$

$L_{SLIT} \leq (D_{PATCH} - D_{SPREAD})$ $W_{SLIT} \leq \sim 0.5\ K_{1\%}^{-1}$

25X1

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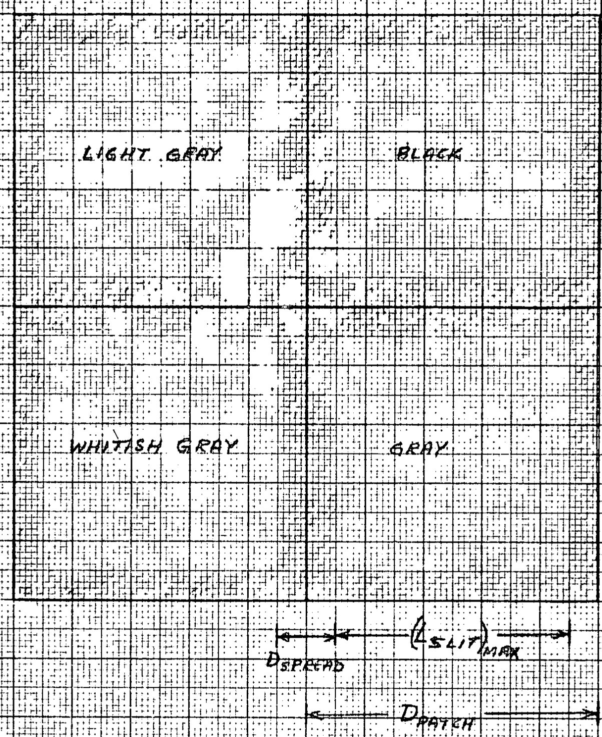
FIG. 4



THUS $D_{PATCH} \geq [L_{SLIT} + 2.26 k_{1\%}]$

FIG 5

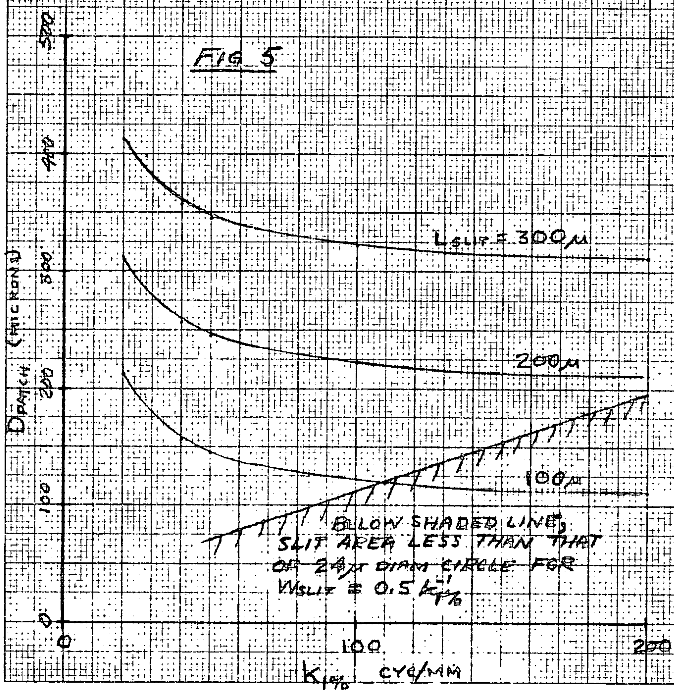


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Fig 6

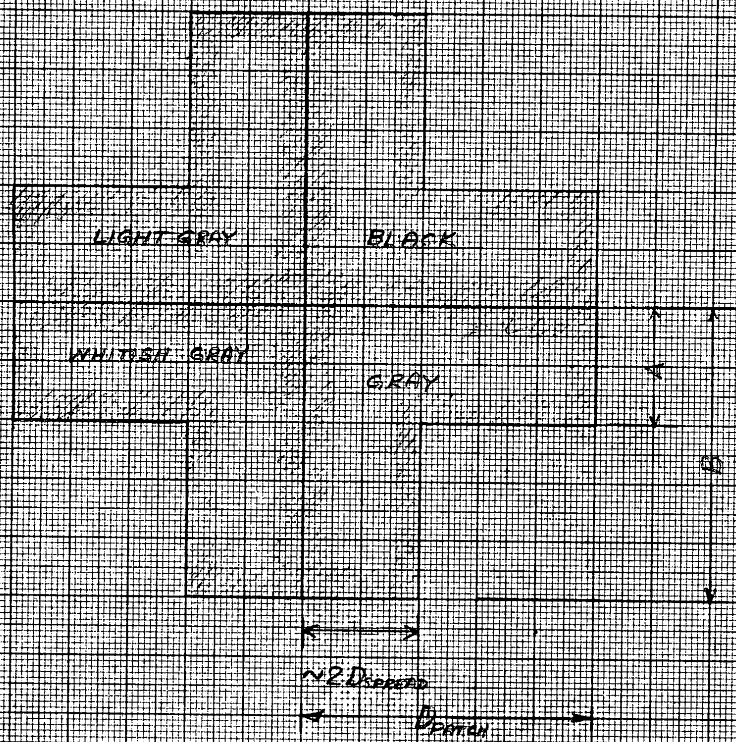

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FIG A-1

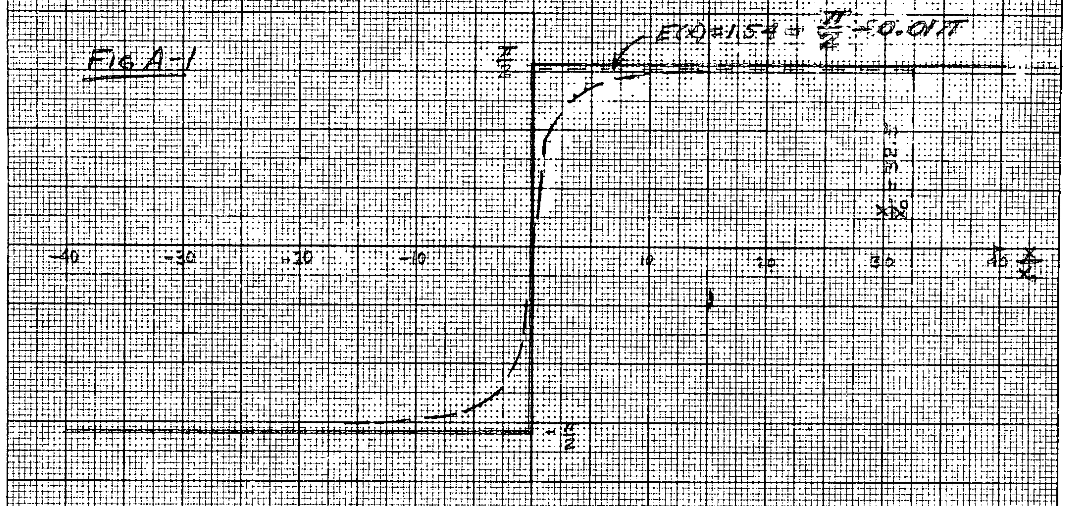
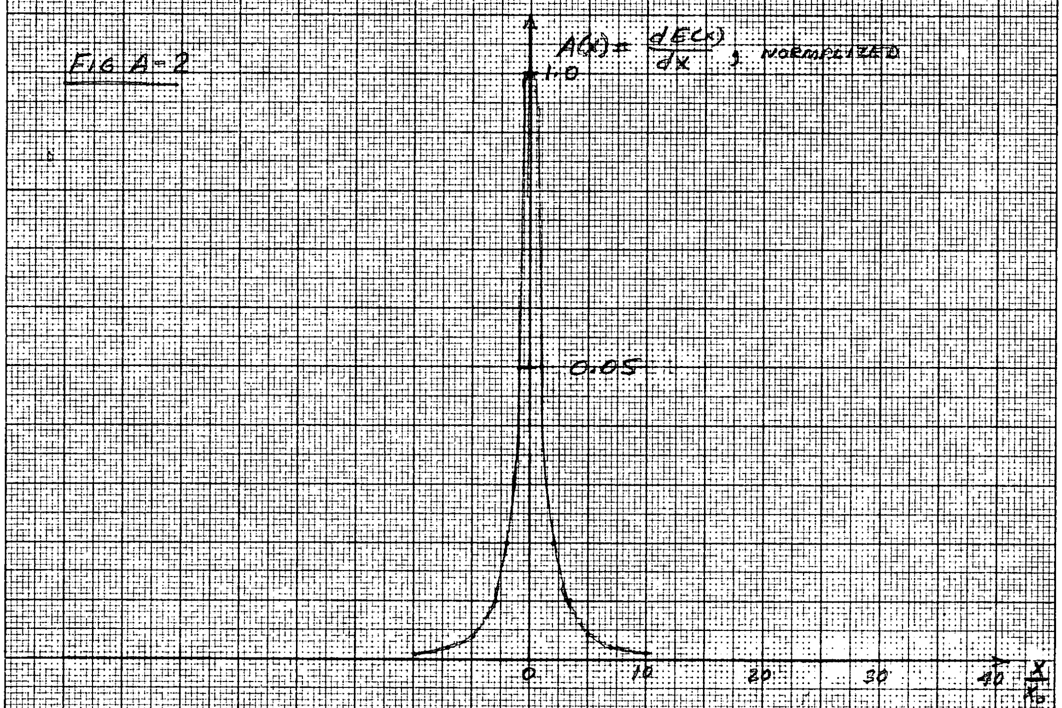


FIG A-2



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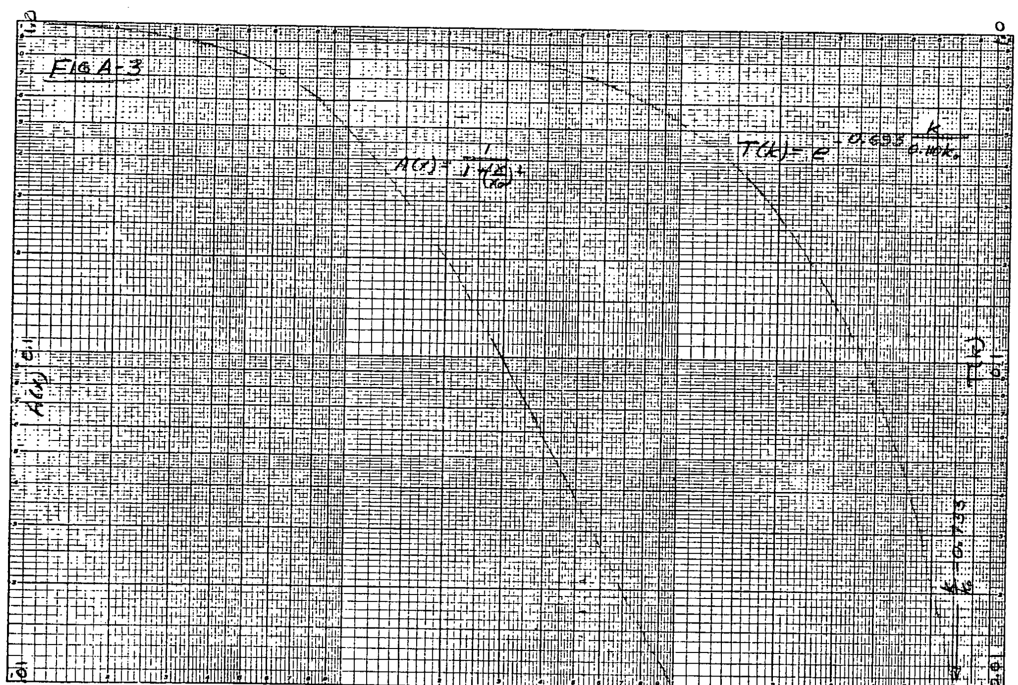
NO. 31.125. LOGARITHMIC: 3 BY 2 3-INCH CYCLES. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS. PRINTED IN U.S.A.

FIG A-3



$D'_{SPREAD} = 2(32.5x_0) = 65(x_0) = 65\frac{1}{k_0} = 65\left(\frac{0.733}{k_{1\%}}\right) = 47.5\,k_{1\%}^{-1}$

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25X1

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FIG A-4

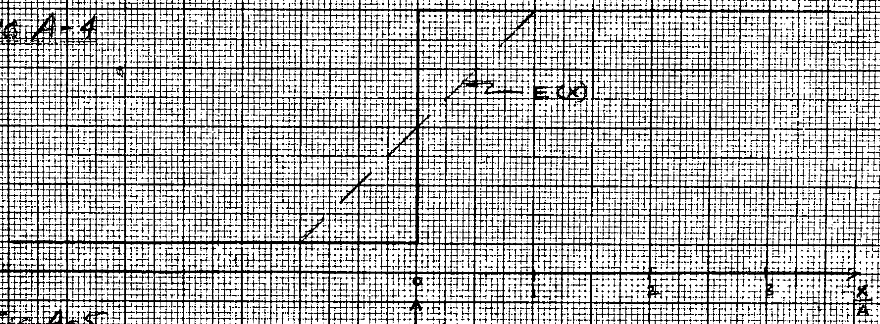


FIG A-5

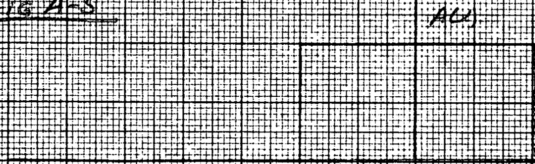
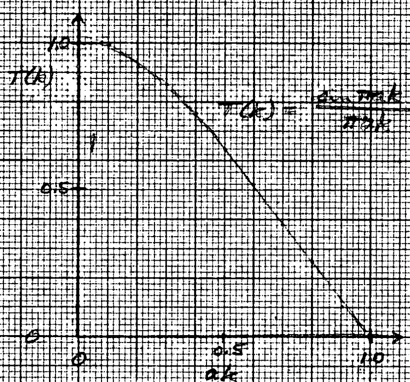


FIG A-6



$D''_{SPREAD} \cong 2A \cong k^{-1}$

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SYSTEM	ASSUMED $k_{1\%}$ (L/mm)	D_{SPREAD} (μ)	A ($=2D_s\frac{h}{f}$) (Ft)	ASSUMED L_s (μ)	B ($=[D_{spr}+L_s]\frac{h}{f}$) (Ft)
C	100	22.6	54	100	148
	50	45.2	108	50	114
G	100	22.6	17	100	46
	50	45.2	34	50	36
HYPO-THETICAL 120 in. FOCAL LENGTH	200	11.3	5	200	51
	100	22.6	11	100	30
	50	45.2	22	50	23
RECOMMENDED SIZES (INCL. CONTINGENCY)			120		200